ITS-G5 technology – A Fact Sheet.

Introduction.

The European Commission is currently drafting a legal framework on Cooperative Intelligent Transport Systems (C-ITS). This upcoming 'delegated act' on C-ITS would be subordinated to the ITS Directive 2010/40/EU. It would address direct short-range communication between C-ITS stations, be they installed in vehicles, at the roadside or on infrastructure, such as traffic lights. This is necessary to guarantee that communication is interoperable, reliable, secure and backward compatible – all key principles which are defined in the ITS Directive.

As leading manufacturers of ITS systems and conformity assessment bodies, we argue in favour of this framework for the overall purpose of road safety.

Public authorities, OEMs and road operators have worked together to create a cost-efficient low-latency communication system. This is also referred to as V2X — where the 'V' is a vehicle and the 'X' can be other vehicles, roadside infrastructure or smart devices — and it provides direct connections within a C-ITS context. Communication between vehicles enables them to have a clearer understanding of their direct environment. This improves road safety, traffic management and the environmental performance of road transport. In the EU, the only commercially available short-range V2X technology is called ITS-G5, which is based on the IEEE 802.11 standard (casually referred to by its brand name WiFi) and standardized in Europe as ETSI EN 302 663. In the US, the ITS-G5 technology is also referred to as WAVE (wireless access in vehicular environments) technology or DSRC - Dedicated Short-Range Communication. A broad number of manufacturers in Europe and beyond are able to provide ITS-G5 technology solutions already today.

The focus of this paper is on road safety. It addresses short-range V2X technologies only. It does not cover applications based on existing and future cellular long-range communication networks (3G, 4G and 5G). Long-range cellular communication networks are not suited for low-latency road safety use-cases. They do, however, play a key role in transmitting larger volumes as well as non-time critical data to vehicles. In this paper we also do not cover convenience and awareness services, such as navigation, or cloud services. These services can already be provided today and do not require regulation in the context of road safety.

ITS-G5 is best suited for road safety.

ITS-G5 technology is tailor-made for road safety applications. ETSI EN 302 663 is the only standard to offer the low latencies that are essential for vehicles travelling at high speed. Since it is a wireless technology, it can communicate beyond the line-of sight, e.g. around corners, and complements in-vehicle sensors. Since it is a broadcast technology, it can also communicate to many vehicles and other relevant recipients at once. Its properties make it suitable for numerous road safety applications, such as reduction of fatalities by vulnerable road users, electronic emergency brake light, distance-keeping in platoons of trucks and for future higher levels of more automated driving. It is designed to operate at short-range.

ITS-G5 and WAVE technologies do not require any network coverage or roadside units to exchange messages. Communication takes place whenever vehicles or C-ITS stations are within range of each other, as they can form ad-hoc networks. Whilst not requiring any network coverage, road operators may opt to equip critical spots on their road infrastructure, such as traffic lights or intersections, to improve road safety. This may make sense, particularly in the beginning, when the penetration rate of the vehicle fleet is still growing.

ITS-G5 technology is designed to be operated on the 5.9 GHz frequency band and fulfils the requirements set out by ETSI EN 302 571 and the ITS Directive 2010/40/EU. ITS-G5 and WAVE technologies are tried and tested in many European and US projects: the simplicity and efficiency with which it uses radio spectrum also makes it a very robust V2X short-range communication technology.

ITS-G5 protocol technology also meets all requirements to operate under the European Commission's Security Policy[1] and Security Certification Policy[2], which assure the trustworthiness of messages sent using C-ITS.

As current ITS-G5 systems are developed by automotive suppliers, functional safety like compliance with the Automotive Safety Integrity Level (ASIL) according to ISO 26262 is already taken into account.

Lately, the cellular standardisation organisation 3GPP has started discussing cellular short-range communication technologies. One of them, LTE-V2X, is based on 4G cellular standards. LTE-V2X is sometimes also referred to as either 3GPP 'Release 14' or 'Release 15'. LTE-V2X proof of concept testing has started recently but few results are publicly available. Cross-border tests or cross-brand tests are unknown so far. Very recently, discussions on 5G-based cellular short-range communication have also started; these concern 3GPP 'Release 16'. Together, the 3GPP releases 14, 15 and 16 are also referred to as C-V2X. C-V2X is a short-range communication technology and technically very different from 4G and 5G, which are long-range cellular communication technologies.

[1] Security Policy & Governance Framework for Deployment and Operation of European Cooperative Intelligent Transport Systems (C-ITS) (Release 1, December 2017)
[2] Certificate Policy for Deployment and Operation of European Cooperative Intelligent Transport Systems (C-ITS) (Release 1.1, June 2018)

Implementing the technology – the case of handheld mobile devices ('smart phones').

It is often claimed that only C-V2X enables the integration of handheld mobile devices into ITS use cases, because of the easy integration of LTE-V2X into 4G or 5G chipsets. However, implementing C-V2X in the 5.9 GHz frequency band would require a significant redesign of the LTE chipset as well as other components and cannot be done with an already commercially available smartphone. On the other hand, WAVE and ITS-G5 technology can complement cellular long-range communication and, as far back as 2013[3], has already proven to work in smart phones with no or only minimal hardware changes.

ITS-G5 is the only mature technology for safety critical low-latency V2X applications.

Because it's for road safety, it's designed to be cost efficient.

ITS-G5 applications and technology have been designed for road safety. This is reflected in its pricing. It is based on publicly available standards in order to create an environment in which manufacturers can develop products. This fosters competition and keeps prices moderate. ITS-G5 applications have been elaborated in an inclusive, transparent and technically thorough manner by industry in the European standardisation body ETSI. It has been designed to impose a minimal cost burden upon OEM and road operators. This is of particular importance for facilitating mass deployment.

The absence of a network provider also means that ITS-G5 technology does not accrue any costs for data transmission.

In effect, the main bulk of investment for ITS-G5 technology would be equipping vehicles (96%), whilst investment in roadside equipment is expected to be low (4%)[4].

Due to a different business model, both, C-V2X long- and short-range communication services would very likely come along with license fees for chipsets, which would need to be paid to non-European companies. To date, early C-V2X chipset samples, whose readiness for mass production remains unclear, are only offered by a small group of American and Chinese vendors.

Moreover, 3GPP Releases 14, 15 and 16 suggest that future C-V2X will very likely require significantly different equipment from the regular and already available non-V2X LTE modems. This is also true for the base stations. Currently available LTE base stations would need to be upgraded to cater for C-V2X. Hence, the claim that C-V2X does not require any additional infrastructure and is less costly, does not accord with information available in Releases 14, 15 and 16.

I*TS-G5 technology is designed to cause minimal expense to OEM and road operators, to keep costs for road safety down and allow for an open and competitive market.*

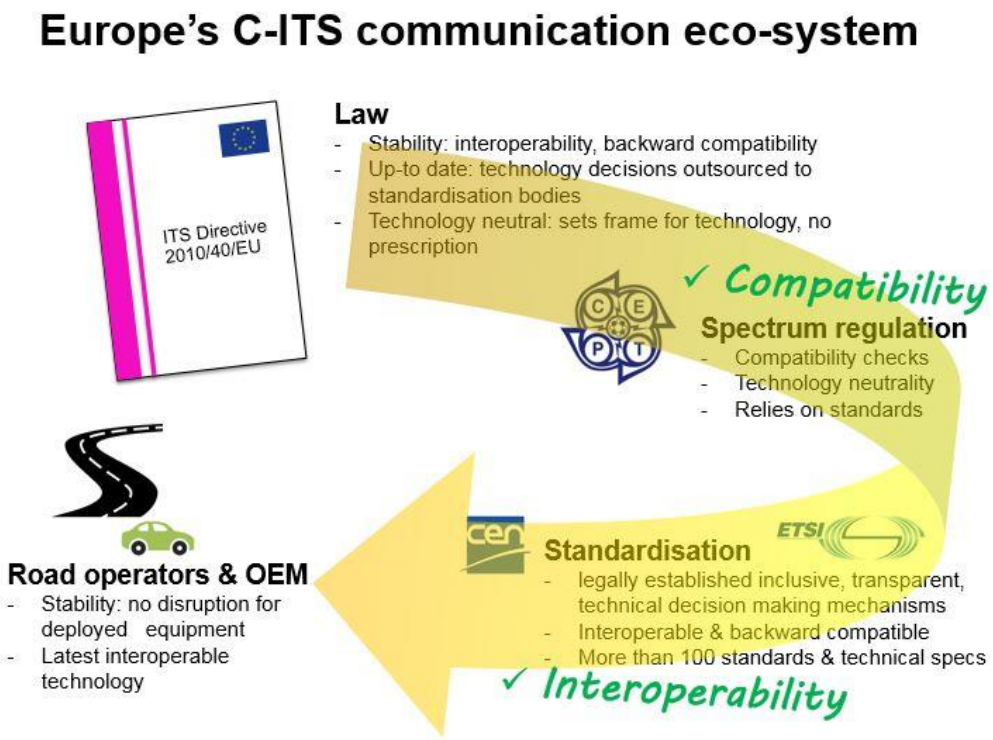
[3] https://www.qualcomm.com/news/onq/2015/06/16/how-snapdragon-and-honda-are-working-save-lives-smartphones; http://cvt-project.ir/Admin/Files/eventAttachments/QCom-Honda-paper-2014-Cars%20Talk%20to%20Phones_625.pdf; http://news.honda.com/newsandviews/article.aspx?id=7352-en

[4] European Commission, Study on the Deployment of C-ITS in Europe, Final Report, February 2016, p1

Because it's for road safety, we need clear requirements.

C-ITS serves road safety. Hence a regulatory framework is required to guarantee the proper functioning of the system. The ITS Directive defines objectives to be specified through delegated acts. Its objective is to ensure that any C-ITS station is able to communicate with any other C-ITS station: they have to be interoperable. Furthermore, C-ITS stations have to be able to communicate throughout the 10-15 year life span of a vehicle or roadside unit: the principle of backward compatibility´ assures this. The ITS Directive also requires technologies to be mature and any deployment to be coherent with other EU policies, such as radio spectrum policy, road user charging or mandated driving and rest times.

The current debate around the delegated act concerns these minimum requirements and how they relate to future technologies.



Mature technology – ITS-G5.

ITS-G5 is the only mature technology at the moment. After more than 10 years of extensive testing, local variations of it are already deployed in Japan and the US. It has started to be more widely deployed in Europe, with progress accelerated through the C-ROADS Platform[5]. Automotive manufacturers, such as Volkswagen Group[6], Toyota[7], General Motors[8] and Daimler Trucks[9] have announced that they are using ITS-G5 and WAVE technologies for V2X communication. Renault[10], PSA[11], MAN[12], DAF, SCANIA and Volvo Trucks[13] are currently piloting ITS-G5.

C-V2X is, at best, at a proof-of-concept stage and needs to undergo thorough testing before reaching maturity. There are currently no LTE-V2X chipsets commercially available. The 5G related short-range communication has not developed far enough for a detailed technical discussion.

We believe that ITS-G5 technology is the only technology that fulfils the maturity criterion of the ITS Directive – Annex II (i).

[5] https://www.c-roads.eu/platform/about/about.html
[6] VW refers to ITS-G5 technology as WLANp or pWLAN: https://www.volkswagen-newsroom.com/en/press-releases/with-the-aim-of-increasing-safety-in-road-traffic-volkswagen-will-enable-vehicles-to-communicate-with-each-other-as-from-2019-1023
[7] Toyota refers to the V2X technology as DSRC, the US IEEE 802.11p related V2X technology: https://corporatenews.pressroom.toyota.com/releases/toyota+and+lexus+to+launch+technology+connect+vehicles+infrastructure+in+u+s+2021.htm
[8] GM refers to the V2X technology as DSRC, the US IEEE 802.11p related V2X technology: https://media.gm.com/media/cn/en/gm/news.detail.html/content/Pages/news/cn/en/2018/June/0606_Cadillac-Lineup.html
[9] Daimler Trucks Highway Pilot Connect runs on IEEE 802.11: https://media.daimler.com/marsMediaSite/en/instance/ko/Highway-Pilot-Connect-networked-trucks-drive-in-a-convoy-for-greater-safety-and-lower-fuel-consumption.xhtml?oid=9905211
[10] Renault: https://media.group.renault.com/global/en-gb/renault/media/pressreleases/21200353/renault-prepare-les-infrastructures-pour-la-voiture-autonome-et-connectee-de-demain-avec-scoop
[11] PSA ‚SCOOP' technology in its vehicles. SCOOP@F is an ITS-G5 technology and application pilot deployment in France: https://media.groupe-psa.com/en/ds-4-and-citro%C3%ABn-c4-owners-can-take-part-scoop-project
[12] MAN: https://www.truck.man.eu/de/en/man-world/man-in-germany/press-and-media/Platooning-in-logistics-applications_-MAN-hands-over-pilot-vehicles-to-DB-Schenker--318080.html
[13] Volvo Trucks: https://www.volvogroup.com/en-en/news/2017/oct/trucks-talking-to-each-other-in-multi-brand-platooning-project.html

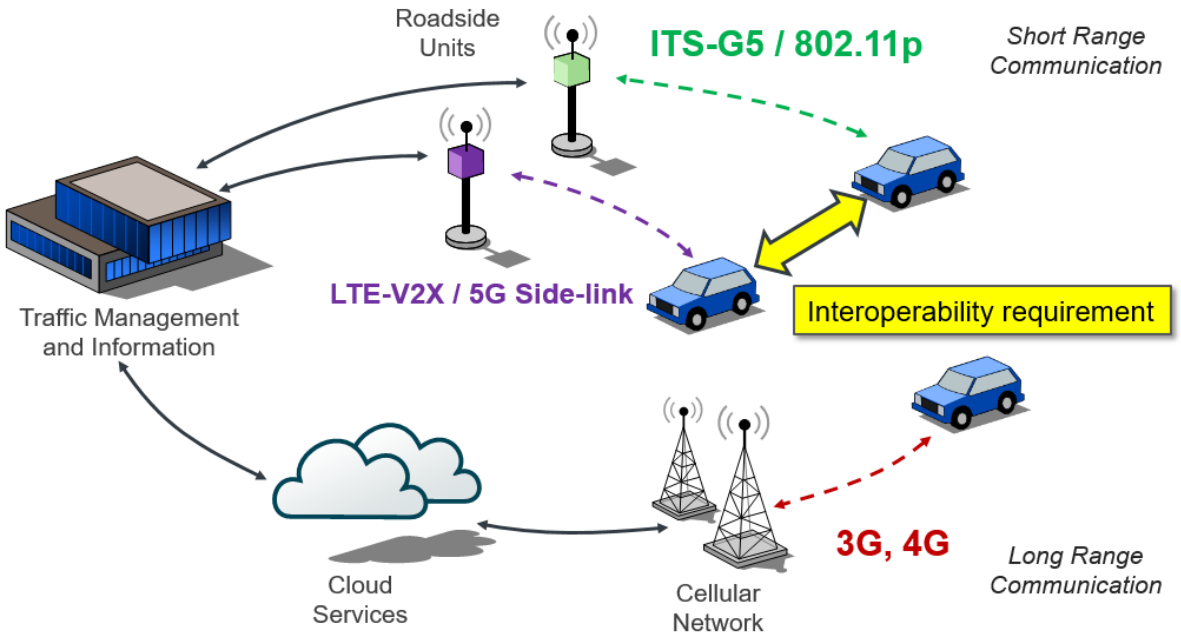
Interoperability.

To maximise road safety gains, all C-ITS stations have to be able to communicate with each other. ITS-G5 is the only available V2X technology. Therefore, to assure interoperability, future technologies have to take the existence of ITS-G5 technology into account.

The ITS-G5 technology and the application software stack have been standardised in the European standardisation body ETSI since 2009 under a European standardisation mandate.[14] Its standards are openly accessible to assure interoperability.

The drafting process of 3GPP Releases 14, 15 and 16 started well after the adoption of the ITS Directive and the European standardisation mandate M/453. Regardless, the interoperability criterion was not sufficiently taken into account. As a result, the 3GPP Releases are not yet able to receive CAM and DENM messages transmitted by ITS-G5 C-ITS stations and vice-versa.

To comply with the ITS Directive - Annex II (e), 3GPP releases have to be interoperable with ITS-G5 technology.



[14] Standardisation mandate M/453

Backward compatibility.

Vehicles, as well as roadside units, have a life-span of 10-15 years. C-ITS has to work reliably throughout this time period. New standards and technologies have to take this into account and should always be able to communicate, no matter the generation of the equipment. The ITS Directive specifically takes this into account and protects existing systems in its Annex II (f), obliging specifications to be 'backward compatible'.

As highlighted, ITS-G5 technology is based on the IEEE 802.11 standard. There are updates to IEEE 802.11p in elaboration, all of which are backward compatible and interoperable. WiFi has a clear evolutionary path. This has been proven over the years, from IEEE standards 'IEEE 802.11n' to 'IEEE 802.11ac' and now the upcoming 'IEEE 802.11ax'. By contrast, 3GPP has itself stated that its Release 14 is not compatible with ITS-G5 technology[15]. Operated in the same spectrum band, they would cause radio interference to each other.

The current state of the debate in 3GPP indicates that: LTE-V2X would not even be able to operate in the same channel with 3GPP Release 16 because they are two different technologies that cannot co-exist[16]. Hence, the claim that LTE-V2X offers an evolutionary path to 5G requires further examination.

Compatibility also concerns systems outside the C-ITS environment: namely electronic road user charging and the digital tachograph that run in an adjacent radio frequency band. Here, ITS-G5 offers a standardised mitigation method to protect them from radio interference. The 3GPP Releases 14, 15 and 16 only specify basic principles concerning compatibility with electronic road user charging and the digital tachograph. Ongoing CEPT studies on this issue show that the existing 3GPP specifications are not sufficient to mitigate interference with electronic road user charging.

LTE-V2X is expected to cause harmful interference to ITS-G5 technology, if it operates in the same frequency band. In the 5.9 GHz frequency band LTE-V2X would not be 'backward compatible'. C-V2X has to still prove compatibility with electronic road user charging and the digital tachograph.

Coherence.

The European Commission's 5G Action Plan clearly envisions 5G as complementary to ITS-G5[17]. The European Commission staff working document on the 5G Action Plan is even more explicit[18]. We adhere to this vision and see ITS-G5 as complementing existing long-range cellular networks, such as 3G and 4G, and in the future 5G. The most cost-effective approach would be a hybrid solution combining short-range ITS-G5 technology with normal cellular long-range technology[19].

[15] 3GPP TSG RAN Meeting #72, Busan, Korea, June 13 - 16, 2016
[16] 3GPP TSG RAN #79/ RP-180426
[17] SWD (2016) 306, p.9
[18] SWD (2016) 306, p.9
[19] "V2X System Cost Analysis: DSRC+LTE and C-V2X+LTE", ABI Research, January 23, 2018

Coherence with European frequency regulation.

In Europe, there are several laws in place that either explicitly refer to ITS-G5 technology to enable backwards compatibility and interoperability, or that specify radio parameters to avoid interference to other radio services. These protected services are NATO communication satellites [20], and other radio services [21]. Some of these radio parameters e.g. the transmission duty cycle cannot be met by LTE-V2X as currently specified. CEPT compatibility studies of how to integrate this new technology into the existing frequency regulation were not conducted.

European frequency regulation does not foresee splitting the 5.9 GHz frequency band into several sub-bands reserved for different technologies, since this would run against the technology neutral use of spectrum as outlined in Decision 243/2012/EU [22]. This Decision demands that the use of spectrum shall: be efficient - i.e. the sharing mechanism shall not waste channel resources; be technology neutral, i.e. all technologies that share the channel must have the same channel access rights/probability; and avoid interference and assure technical quality, i.e. each service shall avoid interference to any other transmissions. Also, the transmission of the same content by two different technologies within the same frequency band would be highly inefficient, and would not conform to Decision 243/2012/EU.

Coherence with other policies.

In order to assure coherence with other EU policies, we require clear specifications.

The delegated act has to be specific enough to allow the protection of already deployed technical systems, such as the digital tachograph. Referring to standards would not lock C-ITS into one technology and nor would it contradict the concept of 'technology neutrality'[23]. Instead, naming standards would simply set minimum requirements for the entry of any technology into the C-ITS market.

Overall, it has to be kept in mind that under specific circumstances the concept of 'technology neutrality' can be limited through factors, such as general public interest, fulfilment of EU law, proper functioning of services and the avoidance of harmful interference. Accordingly, for delivering on/implementing an essential public good like road safety, it would in principle be possible to make qualifications to the concept of technology neutrality.

Only a clear reference to standards and specifications guarantees coherence with other European Union rules, policies and activities relevant in the field of ITS.

[20] NATO MILITARY ASSESSMENT https://cept.org/Documents/cpg/37302/cpg-17-info31_nato-pnma-on-wrc-19
[21] CEPT Report 57https://www.ecodocdb.dk/download/33104cff-3926/CEPTREP057.PDF
[22] Decision 243/2012/EU establishing a multiannual radio spectrum policy programme, Article 2 (1)
[23] Directive 2009/140/EC, Recital 35

Glossary:

C-ITS:	Ad-hoc short-range communication using one trust system, subject of the C-ITS delegated act that will specify it in detail.
C-V2X:	Ambiguous term referring to a mix of cellular short-range communication, either 3GPP Release 14 and 15 (LTE-V2X) or 3GPP Release 16 (5G related short-range communication), and cellular long-range communication.
DSRC:	Dedicated Short Range Communication – this term is used differently in the US and Europe. In Europe it used to refer to the European CEN DSRC tolling standards, that operates on the 5.8 GHz frequency band. In the US the term refers to ad-hoc short-range communication, no matter the frequency band.
ETSI:	One of the three European standardization organization mandated to draft European Norms.
IEEE 802.11p:	The 'root standard' of ITS-G5, pWLAN (sometimes also referred to as WLANp), WAVE (US version of ITS-G5) and DSRC. The IEEE 802.11 standards are called WLAN or WiFi standards in general, the 'p' a particular standard for use in vehicles. IEEE is a standardisation organization and stands for Institute of Electrics and Electronical Engineers.
ITS-G5:	A wireless short-range communication technology tailor made for vehicle-to-vehicle communication, transports small data volumes extremely fast. It is standardized under ETSI EN 302 663. The name G5 is derived from the frequency band (5.9GHz), and not from 5G technology, despite the similar name. Volkswagen Group refers to ITS-G5 technology as pWLAN or WLANp.
LTE-V / LTE-V2X:	Interchangeable terms for a future short-range communication technology based on 4G. The latest standards are the 3GPP Release 14 and 3GPP Release 15. Not yet standardised at European level.
V2X:	Vehicle to everything communication.
3G:	Cellular network of the 3rd generation.
3GPP:	A standardization organisation specialised in cellular standards, works closely with ETSI.
4G:	Cellular network of the 4th generation, also known as LTE. It is capable of transmitting more data than 3G and faster.
5G:	Future cellular network, the 5th generation, offer higher data-rates than 4G.